

Critical Surface Cleaning and Verification Alternatives

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Abstract

As a result of federal and state requirements, historical critical cleaning and verification solvents such as Freon 113, Freon TMC, and Trichloroethylene (TCE) are either highly regulated or no longer available. Interim replacements such as HCFC 225 have been qualified, however toxicity and future phase-out regulations necessitate long term solutions.

The scope of this project was to qualify a safe and environmentally compliant LOX surface verification alternative to Freon 113, TCE and HCFC 225. The main effort was focused on initiating the evaluation and qualification of HCFC 225G as an alternate LOX verification solvent. The project was scoped in FY 99/00 to perform LOX compatibility, cleaning efficiency and qualification on flight hardware.

Introduction

HCFC 225G, is a cleaning solvent that is an environmentally compatible alternative for HCFC 225 in the areas of metal cleaning, vapor degreasing, and flushing. The major difference between HCFC 225 and HCFC 225G is that HCFC 225G is a single component (3,3-Dichloropentafluoropropane), while HCFC 225 is a two component system (3,3-Dichloropentafluoropropane and 1,3-Dichloropentafluoropropane). By removing the 1,3 isomer HCFC 225G is less toxic than the HCFC 225 product. The respective Threshold Limit Values (TLV) are 250 ppm versus 25 ppm.

Body

A) LOX Compatibility Evaluation of HCFC 225G

The technical approach was to evaluate HCFC 225G for LOX mechanical impact sensitivity testing with liquid oxygen by the procedure outlined in NHB 8060/NASA STD-6001 Test 13 Part #1.

Duplicate lots of Freon 113, HCFC 225G, and HCFC 225 were tested per NHB8060.1B/NASA-STD-6001, test 13A, at Marshall Space Flight Center (MSFC) for LOX compatibility. All solvents submitted passed LOX compatibility tests, as shown in Table 1.

Table 1 LOX Compatibility Test Results

MATERIAL	LOT	TESTS	RESULTS
HCFC 225G	59704211	0/20	PASSED
Freon 113	N/A	0/20	PASSED
HCFC 225	3114	0/20	PASSED

B) HCFC 225G Cleaning Efficiency

The technical approach to evaluate HCFC 225G cleaning efficiency was by applying E.T. contaminants to 2219 Al test panels. Gravimetric analysis was performed in order to determine the percent removal cleaning efficiency for each of the respective contaminants.

The evaluation of the HCFC 225G consisted of preparing Al-2219 test panels for three (3) of the most common E.T. contaminants (J-414 Tape Residue, Safe Tap and CRC 2-26). The respective test panels were weighed before and after the contamination process with each of the respective E. T. contaminants. HCFC 225G was flushed onto the contaminated surface with a controlled stream of 500 mL of solvent from a pressurized vessel that emulated the current process. The test panels were flushed from top to bottom to insure contact with the entire contaminated surface. After flushing, each test panel was placed in a desiccator for 24 hours and then weighed to a constant weight. A percent (%) cleaning efficiency was calculated for each solvent and its respective test panels as shown in Table 2 through 4. Based upon the overall percent removal cleaning efficiency of the three major E.T. contaminants, HCFC 225G cleaning solvent was recommended for additional qualification testing on flight hardware.

Table 2
HCFC 225G Cleaning Efficiency of Safe-Tap Drilling Lubricant

PANEL #:	INITIAL WT.	CONT. Panel Wt.	CONT.	CLEANED WT.	AMT. REMOVED	% CL. EFF
S1	139.107	139.116	0.009	139.108	0.008	88.89
S2	138.542	138.549	0.007	138.541	0.008	114.29
S3	138.164	138.170	0.006	138.164	0.006	100.00
S4	139.914	139.921	0.007	139.913	0.008	114.29
S5	139.085	139.091	0.006	139.085	0.006	100.00
S6	139.537	139.547	0.010	139.537	0.010	100.00
S7	139.889	139.898	0.009	139.889	0.009	100.00
S8	139.593	139.601	0.008	139.592	0.009	112.50
S9	139.531	139.538	0.007	139.530	0.008	114.29
S10	138.939	138.945	0.006	138.938	0.007	116.67

Average 106.09

Table 3
HCFC 225G Cleaning Efficiency of CRC 2-26 Hydrocarbon Oil

PANEL #:	INITIAL WT.	CONT. Panel Wt.	Cont.	CLEANED WT.	AMT. REMOVED	% CL. EFF
C1	138.974	138.997	0.023	138.975	0.022	95.65
C2	138.753	138.775	0.022	138.753	0.022	100.00
C3	138.818	138.830	0.012	138.817	0.013	108.33
C4	139.110	139.140	0.030	139.11	0.030	100.00
C5	139.520	139.548	0.028	139.52	0.028	100.00
C6	138.587	138.602	0.015	138.586	0.016	106.67
C7	139.653	139.672	0.019	139.653	0.019	100.00
C8	139.285	139.304	0.019	139.286	0.018	94.74
C9	138.406	138.423	0.017	138.406	0.017	100.00
C10	139.773	139.805	0.032	139.771	0.034	106.25

AVERAGE 101.16

Table 4
HCFC 225G Cleaning Efficiency of J-414 Tape Residue

PANEL #:	INITIAL WT.	CONT. Panel Wt.	Cont.	CLEANED WT.	AMT. REMOVED	% CL. EFF
T1	139.441	139.448	0.007	139.442	0.006	85.71
T2	139.936	139.94	0.004	139.936	0.004	100.00
T3	139.193	139.196	0.003	139.194	0.002	66.67
T4	139.922	139.925	0.003	139.923	0.002	66.67
T5	139.816	139.818	0.002	139.817	0.001	50.00
T6	139.300	139.305	0.005	139.301	0.004	80.00
T7	139.831	139.839	0.008	139.834	0.005	62.50
T8	140.236	140.243	0.007	140.239	0.004	57.14
T9	139.052	139.154	0.102	139.048	0.106	103.92
T10	140.061	140.066	0.005	140.062	0.004	80.00

Average 75.26

HCFC 225G performed better than Freon 113 (PCA) as a cleaning solvent replacement for HCFC 225. HCFC 225 is the current implemented replacement for Freon 113 (PCA). Percent (%) cleaning efficiency comparative results are listed in Table 5. Therefore a qualification plan was established to compare Freon 113 (PCA) and HCFC 225 to HCFC 225G as baselines for all replacement solvent.

Table 5
Percent (%) Cleaning Efficiency Comparative Results

Contaminant	Solvent	Average % Efficiency
CRC 2-26 Oil	Freon 113	98.4
	HCFC 225	91.8
	HCFC 225G	101.0
Safe Tap	Freon 113	64.7
	HCFC 225	96.6
	HCFC 225G	106.0
J-414	Freon 113	61.3
	HCFC 225	31.5
	HCFC 225G	75.2

C) Perform Qualification of HCFC 225G as an Alternative Cleaning Solvent for HCFC 225

The technical approach to support qualification was to evaluate replacement solvent cleaning ability on the following flight and non-flight items:

20 ft LOX feedline (80971028425-010)
LH Clean Kit (80924061028M900)
Tube Assembly (80923021036-050)
Mask Tool (non-flight), T31K2026

The plan consisted of cleaning flight hardware per Marshall Space Flight Center specification MSFC-SPEC-164B or C and process instruction (PI) 5008. Four (4) representatives of flight hardware were selected to evaluate using HCFC 225G per NASA's operational directive (99/OD/0571).

The flight hardware cleaning evaluation consisted of flushing metallic flight hardware with HCFC 225G by the clean-room operators, upon completion an NVR sample was taken and analyzed. After each cleaning and NVR verification with HCFC 225G, an NVR verification sample (500 mL) of the hardware was immediately taken using HCFC 225 and analyzed to insure that the removal of the organic production contamination had been accomplished with HCFC 225G. Two (2) tube assemblies were evaluated in FY 00. The results are shown in Table 6.

Table 6
Flight Hardware Qualification Results

Flight Hardware	Solvent	MG/FT2
Tube Assembly	HCFC 225G	1.5
	HCFC 225	0.7
Tube Assembly	HCFC 225G	1.6
	HCFC 225	0.7

The results in Table 6 indicate HCFC 225G removed the contamination to an acceptable level of 1 mg/ft2. The outstanding flight hardware qualification items will be evaluated in FY 00. In summary HCFC 225G is an excellent cleaning and verification solvent for common External Tank contaminants.